Ultra-Long Duration Balloon
Control Center
Preliminary Design Report

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Signature Page

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1.0 Introduction

Recent advances in composite super-pressure balloon materials have greatly enhanced the prospects for very long duration balloon flights on Earth as well as possible use for planetary exploration. NASA is embarking on the development of technologies to support extended balloon missions lasting up to 100 days (~5 circumnavigations of the globe) above 99.9% of Earth's atmosphere.

The Ultra Long Duration Balloon (ULDB) objective is to develop a low cost, integrated, advanced, long duration balloon system which is technically feasible and within program cost constraints while maintaining the existing balloon program. The ULDB program is significantly different from the current balloon program in that the expected science return is significantly greater than current balloon missions. In other words, it is more than simply extending current experiments over a longer time period. This program also expects to use technologies currently available in the spacecraft missions and commercial arenas to improve performance while containing costs.

The purpose of the ULDB Control Center software effort is to provide ULDB scientists, engineers, and mission operators with software tools with which they can monitor the status of and issue commands to ULDB instruments. The control center systems will support integration, pre-launch checkout, launch, float, and terminate operations.

1.1 Purpose

The document describes the preliminary design of the ULDB Control Center. It presents the functional description of the control center systems and forms the basis for the detailed design.

1.2 Applicable Documents

1.2.1 Project Documentation

The following ULDB project documentation is applicable and/or related to this document.

ULDB Design-To Requirements Document, revision 1.2, December 3, 1997,
http://www.wff.nasa.gov/~uldb/designreqmts.pdf

1.2.2 Subsystem Documentation

The following ULDB Control Center specific documentation is applicable and/or related to this document. These documents are available via the ULDB Control Center page:
http://www.wff.nasa.gov/~code584/ULDBControlCenter/uldbcontrolcenter.html.

ULDB Control Center Product Plan
ULDB Control Center Software Development Management Plan
ULDB Control Center Requirements and Functional Specifications
ULDB Control Center Operations Concept Document

2.0 Design Overview

Government Off-the-Shelf (GOTS) product. This design meets or exceeds all of the ULDB Control Center requirements at a minimum cost and schedule impact.

2.2 Reuse Strategy

There are several reuse opportunities in the development of the ULDB Control Center.

2.2.1 LDB MPT

The Long Duration Balloon (LDB) Mission Planning Terminal (MPT) used to schedule LDB contacts with the Space Network (SN) will be reused for ULDB.

2.2.2 ITOS

The ITOS control center system originally developed for small explorer satellites will serve as the basis for the ULDB Control Center.

2.3 Alternative Designs

Several alternative design approaches were considered for the ULDB Control Center.

2.3.1 Modified LDB Control Center

A modified version of the existing LDB Control Center configuration was considered as a candidate for the ULDB project. However, the ULDB mission differs significantly from typical LDB missions and different requirements must be satisfied. The cost and effort associated with updating the existing LDB systems increased the risk to the project schedule.

2.3.2 In-House Development

ULDB Control Center specific systems developed in-house was a design approach considered. However, the risk to the project schedule and budget was determined to be unacceptable high.

2.3.3 Off-the-Shelf Products

A variety of COTS products are available that may be applicable to the ULDB Control Center development effort. While a completely COTS solution is feasible, an equally acceptable Government Off-The-Shelf (GOTS) product exists. This product, in conjunction with some low cost COTS products is the design approach of choice for this project. This configuration mitigates risks associated with unreliability and cost while satisfying all of the ULDB Control Center requirements.

3.0 Operations Overview

The ULDB Control Center will include several systems that are designed to coordinate communication between scientists, engineers, and operations personnel and the balloon-craft and science instruments. A fixed computer-based data handling and processing system will be provided to support flight, flight contingency terminate, and terminate operations. This system will be placed in the ULDB Operations

The OCC and the ROCC will use and support the Space Network (SN), INMARSAT, Iridium, and ARGOS networks to obtain forward and return link data communications. In addition, the ROCC will use and support Line-of-Sight (LOS) networks. Both systems will provide tools used to manage the planned operations of the ULDB missions. The systems will provide the capability to receive, process, and monitor telemetry data from the balloon-craft. It will provide the capability to validate, build, up-link, and verify real time commands for the ULDB balloon-craft and instruments. It will provide up-link and verify memory loads for the balloon-craft and instruments and verifies execution of stored commands for the balloon-craft and instruments during a real time contact. The systems will provide a Project Data Base (PDB) containing information necessary to support mission operations. Telemetry, command, and constraint definitions will be maintained within a PDB for each mission. The system will include Operations and Engineering interfaces that provide users with the ability to monitor and control the balloon-craft instruments. The systems will provide analysis capabilities to maintain the health and safety of the ULDB balloon-craft and instruments. The analysis function will provide ULDB operations personnel with the tools necessary to perform balloon-craft systems management, performance analysis, trend analysis, fault detection, isolation, and recovery, and configuration management.

A computer-based software system shall be provided to monitor balloon-craft and science instruments and provide limited control of those instruments. This system shall be referred to as the Remote Monitor and Control System (RMCS).

4.0 Design Description

Six OCC/ROCC functional areas have been identified in compiling the ULDB Control Center requirements: General System, Telemetry Acquisition, Command, Data Management, Real-time Monitor and Control, and Data Analysis. ITOS, with some modifications, will satisfy all of the General System, Telemetry Acquisition, Command, and Data Management functions. Furthermore, ITOS will also satisfy many of the Real-time Monitor and Control and some of the Data Analysis functions.

Originally designed for detailed testing of satellite components during integration, ITOS has evolved into a Mission Operations Center for a number of satellites. It is a highly configurable, reliable hardware/software configuration with an extensive list of features including the following:

- ✓ Distributed software architecture
- ✓ Database driven
- ✓ Low per-seat cost
- ✓ Accepts telemetry at >4 megabits/second
- ✓ Extracts and monitors data at >64 kilobits/second
- ✓ Archives and plays back telemetry data
- ✓ Displays data via traditional display pages, strip charts, plots, and via Java applets over the world wide web
- ✓ Outputs data to external applications
- ✓ Outputs commands in a variety of encapsulations

To enhance the ITOS Monitor and Control capabilities two COTS products will be integrated. National Instruments Corporation's LabVIEW will be used to expand and enhance the engineering displays.

5.0 Data Interfaces

This section describes the communication links to the ULDB Control Center systems. Additional communication link specific details are presented in Appendix A: Communication Link Specific Data Descriptions.

5.1 OCC

The OCC will accept input from and direct output to several communication links. See Figure 5.1-1.

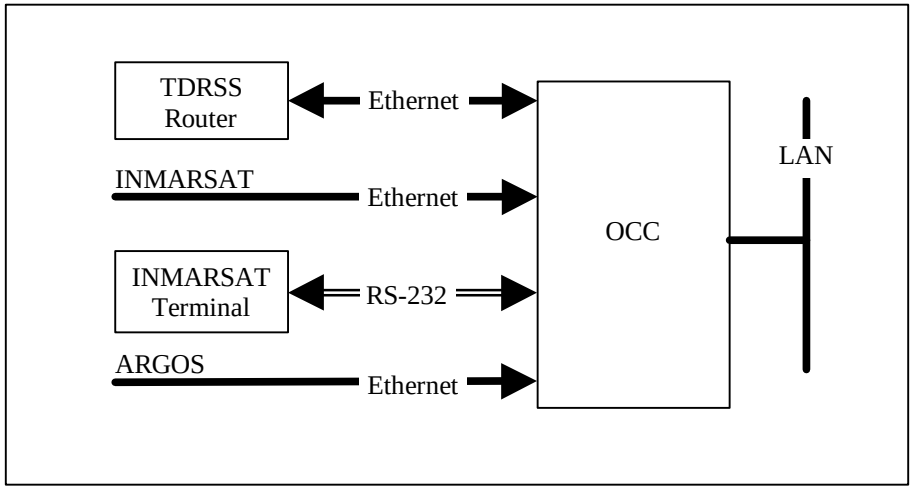

Figure 5.1-1

5.1.1 TDRSS

TDRSS will be used as the primary carrier for balloon-craft and science data. Data will be delivered to the OCC from the TDRSS Router via Ethernet. Balloon-craft and science instrument commands will be forwarded from the OCC to TDRSS via Ethernet for uplink to the balloon-craft.

5.1.2 INMARSAT

The OCC will receive balloon-craft data and some science data from INMARSAT via Ethernet. It will also receive data from the local INMARSAT terminal via an RS-232 connection. Commands to be relayed to ULDB will be forwarded to the local INMARSAT terminal via the RS-232 port connection.

5.1.3 ARGOS

Balloon-craft housekeeping data will be received from ARGOS via Ethernet.

5.2 ROCC

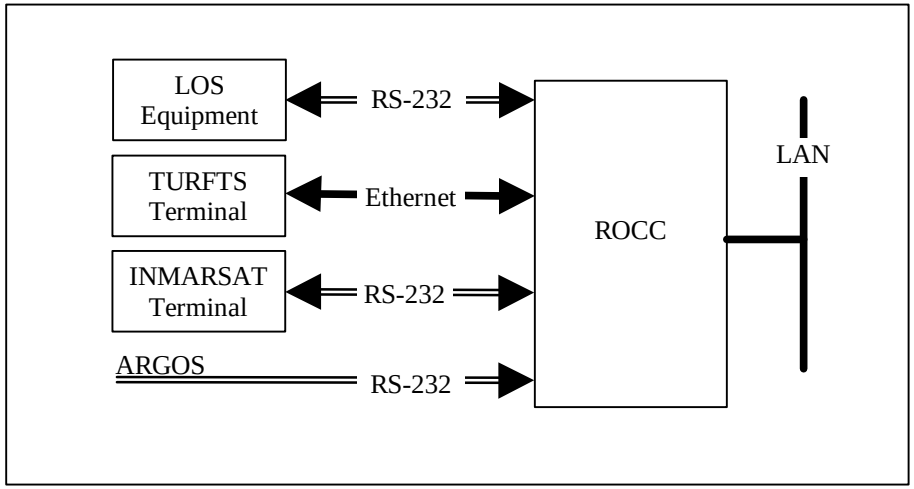

Figure 5.2-1

5.2.1 LOS

The primary carrier for forward and return link communication at the ROCC will be the local line of sight (LOS) ground station equipment. There will be an RS-232 connection between the LOS equipment and the ROCC.

5.2.2 TURFTS

During integration and test and pre-launch checkout, the TDRSS Users RF Test Set (TURFTS) system will send data to the ROCC. Data will be delivered to the OCC from the TDRSS Router via Ethernet. Balloon-craft and science instrument commands will be forwarded from the OCC to TDRSS via Ethernet for uplink to the balloon-craft.

5.2.3 INMARSAT

The OCC will receive balloon-craft data and some science data from the local INMARSAT terminal via an RS-232 connection. Commands to be relayed to ULDB will be forwarded to the local INMARSAT terminal via the RS-232 port connection.

5.2.4 ARGOS

Balloon-craft housekeeping data will be received from ARGOS via RS-232.

5.3 RMCS

Manager's Handbook for Software Development NASA ID: SEL-84-101

Ultra Long Duration Balloon (ULDB) Program Study: Interim Report (Polidan Study): http://lheawww.gsfc.nasa.gov/docs/balloon/ULDB_study/DAYBAL_4.html

Appendix A: Communication Link Specific Data Descriptions

TDRSS Data Description
Data will be streamed in CCSDS standardized packets and convolutionally encoded by either a custom PC-104 board or the TDRSS transceiver. Development of the CCSDS header and data packets needs to be completed before a full understanding of what this data will look like. The I and Q data rate streams shall be command configurable. I data shall always be real time data while Q shall be real time (R/T) half of the time and playback (P/B) the other half. A mode known as combined data streams allows both I and Q data to be combined on the ground yielding a 3 dB gain in signal strength. The following is a table of the various programmable rates for each data channel:

Antenna	I Channel Rate	Q Channel Rate	Combined
Omni	4kb/s real-time	4kb/s real-time	Yes
Omni	2kb/s real-time	2kb/s playback	No
Directional	50kb/s real-time	50kb/s real-time	Yes
Directional	25kb/s real-time	25kb/s playback	No
Directional	150kb/s real-time	150kb/s real-time	Yes
Directional	75kb/s real-time	75kb/s playback	No

These 6 different data rate selections shall be selectable via open collector HSK stack relay commands sent to the flight computer from the ground. Ground control must convolutionally decode TDRSS data since it is encoded in flight. Thus, the ground station must be configured accordingly to be able to sync and decommutate data from TDRSS.

INMARSAT
Data from this terminal is 7-bit ASCII. The 8th bit is for parity. Since all data flows are to be represented as NRZ-L (Binary) streams, this means the flight computers must convert this to ASCII before INMARSAT recognizes it. Ground control must then decode the ASCII streams to NRZ-L for decommutation.

LOS
LOS is strictly NRZ-L data. The CCSDS standard will be adopted for this link.

ARGOS
NRZ-L data shall be streamed on each id with a CCSDS header. ARGOS operates by transmitting a factory programmable ID capable of flowing 32 bytes of data on it. However the new ARGOS transmitters now operate with 8 IDs each capable of 32 bytes of data yielding a total of 256 bytes total. The ARGOS satellite network operates in a random access mode. This means that not all of the data transmitted via ARGOS is guaranteed to get through. If you happen to be in a heavy traffic flow area of the world, you may only get 5 IDs of data throughout the network. Each ID must have a CCSDS header attached to it to identify what data is on that ID. This limits the maximum data throughput for each ARGOS ID to 24 bytes if an 8 byte header is used for each ID. A failsafe mode shall be enabled for ARGOS allowing the vehicle to be tracked should a failure in communication with the flight computer & ARGOS occur. This mode has a unique ID assigned to it that identifies the failsafe mode. This ID shall be repeated every 60 minutes until